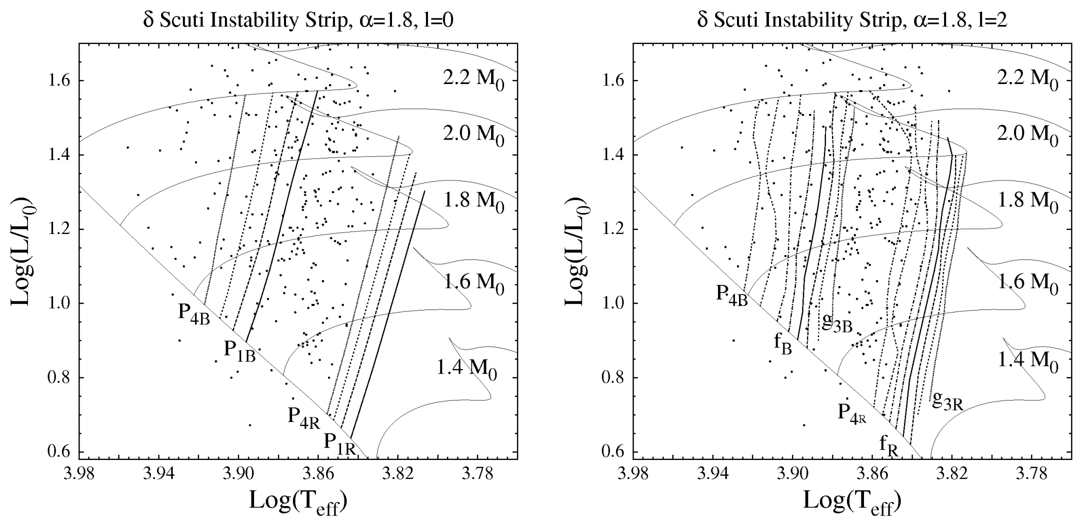

Figure 1: Left panel: Blue and red edges of the δ Scuti theoretical instability strip for models with $\alpha = 1.8$ and radial modes from p_1 to p_4. Right panel: Blue and red edges of the δ Scuti theoretical instability strip for models with $\alpha = 1.8$ and $\ell = 2$ modes from g_3 to p_4. The points correspond to observations.

In the right panel of Fig. 1, we present the theoretical instability strip obtained for $\ell = 2$ modes, for models with $\alpha = 1.8$.

γ Doradus instability strip

The driving of the high-order gravity modes of γ Doradus stars can also be explained by our time-dependent convection models. In the left panel of Fig. 2, we show the periods of all the unstable $\ell = 1$ gravity modes obtained for models of 1.6 $M_\odot$ with $\alpha = 2$, as a function of the effective temperature. Each cross corresponds to an unstable mode. As can be seen, the periods of those modes correspond to the typical observed periods of γ Doradus stars. Moreover, we see in the bottom of this figure that our models have also unstable p-modes, typical of δ Scuti stars. In the right panel of Fig. 2, we show the theoretical instability strips of γ Doradus $\ell = 1$ modes obtained for three families of models with different values of the MLT parameter α: 1, 1.5 and 2. In this case, we give global instability strips and not individual ones for each mode. For any model inside the instability strip, at least one unstable high order g-mode is found; outside it all the g-modes are found to be stable. The small circles correspond to the observed positions of *bona fide* γ Doradus stars from the catalogue of Handler (2002); their effective temperatures are taken from Kaye et al. (1999) who used the calibrations of Villa (1998). As for δ Scuti stars, we see that the theoretical predictions are very sensitive to α. In agreement with Guzik et al. (2000), we find that the depth of the convective envelope plays the major role in the driving of γ Doradus g-modes. This explains the high sensitivity of our results to α.

Conclusion

Including the perturbation of the convective flux, following Gabriel's theory, we obtained theoretical instability strip of δ Scuti and γ Doradus stars. For δ Scuti stars, we succeed to reproduce both the blue and red edges, for radial as well as for non-radial modes. The location of the theoretical red edge appears to be very sensitive to the value of the MLT parameter α. With the solar calibrated value $\alpha = 1.8$, a good agreement with observations is found. We

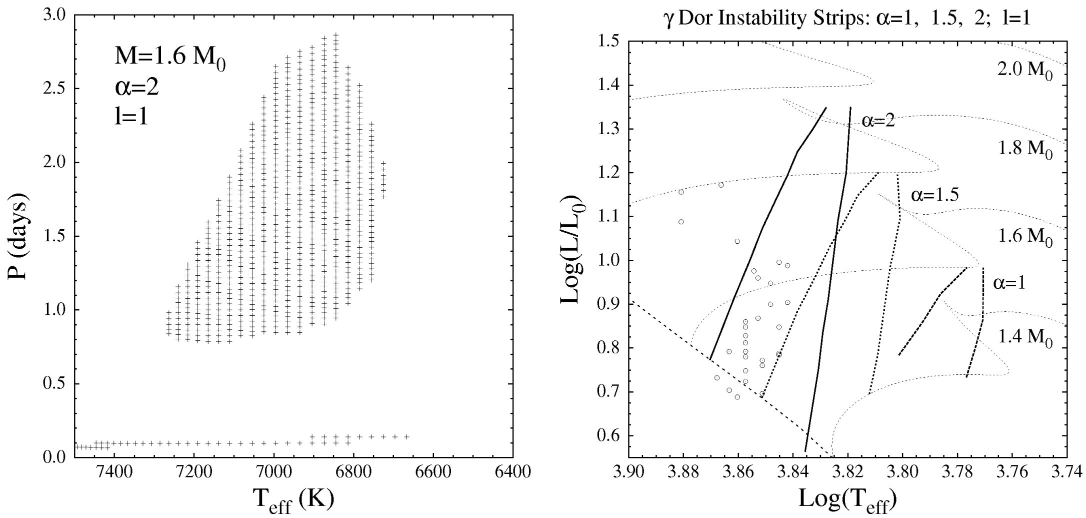

Figure 2: Left panel: Periods (in days) of all the unstable $\ell = 1$ gravity modes obtained for models of 1.6 $M_\odot$ with $\alpha = 2$, as a function of the effective temperature. Each cross corresponds to a given g-mode. Right panel: γ Doradus theoretical instability strips for $\ell = 1$ modes, for three families of models with different values of α: 1, 1.5 and 2. The small circles correspond to observations of *bona fide* γ Doradus stars.

obtained also theoretical instability strips for the γ Doradus g-modes. As for δ Scuti stars, the theoretical instability strips of γ Doradus stars are very sensitive to the value of the MLT parameter α. We obtain good agreement with observations for models with $\alpha = 2$.

Finally, for some models, we found a mixture of unstable p- and g-modes, therefore predicting objects able to show simultaneous γ Doradus and δ Scuti pulsational behaviour.

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Testing the internal physics of white dwarfs from their pulsational properties

J. Isern[1,2], E. García–Berro[1,3], A.H. Córsico[1,2], O.G. Benvenuto[4], L.G. Althaus[1,3]

[1] Institut d'Estudis Espacials de Catalunya, E. NEXUS, c/Gran Capità 2–4, 08034 Barcelona, Spain
[2] Institut de Ciències de l'Espai (CSIC), Edifici Nexus, c/Gran Capità 2–4, 08034 Barcelona, Spain
[3] Departament de Física Aplicada (UPC), Escola Politècnica Superior de Castelldefels, 08860 Castelldefels, Spain
[4] Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Paseo del Bosque S/N,(1900) La Plata, Argentina

Abstract

White dwarfs are well studied objects. The relative simplicity of their physics allows to obtain very detailed models which can be ultimately compared with their observed properties. Among white dwarfs there is a specific class of stars, known as ZZ-Ceti objects, which have a hydrogen-rich envelope and show periodic variations in their light curves. The rate of change of the period is closely related to the star's cooling timescale, which can be accurately computed. In this paper we study the pulsational properties of G117-B15A and we use the observed rate of change of the period to impose constraints on the axion emissivity. This upper bound turns out to be $4\cos^2\beta\,\mathrm{meV}$. Although there are still several observational and theoretical uncertainties, we conclude that G117-B15A is a very promising stellar object to set up constraints on particle physics.

Introduction

Astrophysical arguments and observations have become a well known tool to obtain empirical information or constraints on existing or hypothetical elementary particles. One of the most important reasons for this is that the dense environment of stars is potentially a powerful source of low-mass weakly interacting particles. Since these particles subsequently escape from the star this mechanism constitutes a sink of energy that ultimately modifies the stellar lifetimes, thus allowing a comparison with the observed lifetimes. This is particularly useful since, as it is well known, the different non-standard theories leave open the possibility that several exotic particles (like axions or gravitons) could exist. Moreover, for several of these particles there are not yet laboratory experiments in the relevant mass range that could eventually impose tight constraints on their existence.

Among other weakly interacting massive particles, axions are the most promising candidates for non-baryonic dark matter and, therefore, a great deal of attention has been paid to them. There are two types of axion models, the KVSZ model and the DFSZ model. The first one couples to hadrons and photons whereas the second one also couples to charged leptons. The coupling strength depends on the specific implementation of the Peccei-Quinn mechanism through dimensionless coupling constants that are related to the mass. Both models do not set any constraint on the mass of the axion which must be obtained from experimental tests.